INDIAN ASSOCIATION OF PHYSICS TEACHERS

National Standard Examination in Astronomy - 2024

Date of Examination: December 21, 2024
Time: 2:30 PM to 4:30 PM

Question Paper Code: 45

Student's Roll No:											

Write the Question Paper code (mentioned above) on YOUR OMR Answer Sheet (in the space provided), otherwise your Answer Sheet will NOT be evaluated. Note that the same Question Paper Code appears on each page of the Question Paper.

Instructions to Candidates:

1. Use of mobile phone, smart watch, and iPad during examination is STRICTLY **PROHIBITED.**
2. In addition to this Question Paper, you are given OMR Answer Sheet along with candidate's copy.
3. On the Answer Sheet, make all the entries carefully in the space provided **ONLY** in **BLOCK CAPITALS** as well as by properly darkening the appropriate bubbles.
   Incomplete/ incorrect/ carelessly filled information may disqualify your candidature.
4. On the OMR Answer Sheet, use only **BLUE or BLACK BALL POINT PEN** for making entries and filling the bubbles.
5. Your **Eleven-digit roll number and date of birth** entered on the OMR Answer Sheet shall remain your login credentials (means login id and password respectively) for accessing your performance / result in National Standard Examination in Astronomy – 2024.
6. Question paper has two parts. In part A-1 (Q. No.1 to 48) each question has four alternatives, out of which **only one** is correct. Choose the correct alternative and fill the appropriate bubble, as shown.

Q.No.22 

In part A-2 (Q. No. 49 to 60) each question has four alternatives out of which any number of alternative (s) (1, 2, 3, or 4) may be correct. You have to choose **all** correct alternative(s) and fill the appropriate bubble(s), as shown

Q.No.54 

7. Attempt all sixty questions. For **Part A-1,** each correct answer carries 3 marks whereas 1 mark will be deducted for each wrong answer. In **Part A-2,** you get 6 marks if all the correct alternatives are marked. No negative marks in this part.
8. Rough work may be done in the space provided. There are **11** printed pages in this paper
9. Use of **Non - programmable scientific** calculator is allowed.
10. No candidate should leave the examination hall before the completion of the examination.
11. After submitting Answer Paper, take away the Question Paper & candidate's copy of OMR sheet for your future reference.

Please DO NOT make any mark other than filling the appropriate bubbles properly in the space provided on the OMR Answer Sheet.

Answer Sheets are evaluated using machine, hence CHANGE OF ENTRY IS NOT ALLOWED. Scratching or overwriting may result in wrong score.

DO NOT WRITE ON THE BACK SIDE OF THE ANSWER SHEET.

Instructions to Candidates (Continued) :
You may read the following instructions after submitting the Answer Sheet.

12. **Comments/Inquiries/Grievances regarding this Question Paper, if any, can be shared on the Inquiry/Grievance column on www.iapt.org.in on the specified format till December 26, 2024**

13. **The answers/solutions to this Question Paper will be available on the website: www.iapt.org.in by December 24, 2024.** The score card may be downloaded after Dec 30, 2024

14. **CERTIFICATES and AWARDS:**
Following certificates shall be awarded by IAPT to the students, successful in the NATIONAL STANDARD EXAMINATION IN ASTRONOMY – 2024
(i) "CENTRE TOP 10 %" To be downloaded from iapt.org.in after 30.01.25
(ii) "STATE TOP 1 %" Will be dispatched to the examinee
(iii) "NATIONAL TOP 1 %" Will be dispatched to the examinee
(iv) "GOLD MEDAL & MERIT CERTIFICATE" to all students who attend OCSC – 2025 at HBCSE Mumbai
Certificate for centre toppers shall be uploaded on iapt.org.in

15. List of students (with centre number and roll number only) having score above **Minimum Admissible Score (MAS)** will be displayed on the website: **www.iapt.org.in** by **December 28, 2024. See the MAS clause** on the Student's brochure on the web.

16. List of students eligible to appear for Indian National Astronomy Olympiad (INAO – 2025) shall be displayed on **www.iapt.org.in** by December 31, 2024.

Physical constants you may need….

Magnitude of charge on electron $e = 1.60 \times 10^{-19} C$	Speed of light in free space $c = 3 \times 10^{8}\ ms^{-1}$
Mass of electron $m_e = 9.11 \times 10^{-31} kg$	Speed of sound in dry air at 0°C $v = 332\ ms^{-1}$
Mass of proton $m_p = 1.67 \times 10^{-27} kg$	Permittivity of free space $\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/Nm^2$
Mass of neutron $m_n = 1.67 \times 10^{-27} kg$	Permeability of free space $\mu_0 = 4\pi \times 10^{-7}\ H/m$
Acceleration due to gravity $g = 9.81\ ms^{-2}$	Planck's constant $h = 6.626 \times 10^{-34}\ Js$
Universal gravitational constant $G = 6.67 \times 10^{-11}\ Nm^2/kg^2$	Rydberg constant $R = 1.097 \times 10^{7}\ m^{-1}$
Universal gas constant $R = 8.31\ J / mol\ K$	Astronomical unit $= 1.50 \times 10^{11}\ m$
Boltzmann constant $k = 1.38 \times 10^{-23}\ J / K$	Radius of Sun $R = 6.96 \times 10^{8}\ m$
Stefan's constant $\sigma = 5.67 \times 10^{-8}\ W / m^2 K^4$	Mass of Sun $M = 2.0 \times 10^{30}\ kg$
Avogadro's constant $A = 6.022 \times 10^{23}\ mol^{-1}$	Radius of the Earth = 6371 km
Faraday constant $= 96,500\ C / mol$	Mass of the Earth = 5.97×10^{24} kg

INDIAN ASSOCIATION OF PHYSICS TEACHERS
NATIONAL STANDARD EXAMINATION IN ASTRONOMY
(NSEA - 2024)

Time: 120 minute **Max. Marks: 216**

Attempt All Sixty Questions

A – 1

ONLY ONE OUT OF FOUR OPTIONS IS CORRECT. BUBBLE THE CORRECT OPTION.

1. A choke is necessary if a 50 W, 100 V electric bulb is used across 200 V, 50 Hz a. c. source. Inductance of this choke should be
   (a) 0.1 mH (b) 1.1 mH (c) 0.1 H (d) 1.1 H

2. For a binary star system with two identical stars,
   (a) the stars are always at the same distance from each other.
   (b) Doppler effects of both cancel out each other resulting in a normal spectrum.
   (c) the inclination of the circular orbit with respect to observer does not affect the observed orbital parameters.
   (d) Kepler's law for orbital periods is always applicable.

3. A double star is a system of two stars of masses m and $2m$, rotating about their centre of mass only under their mutual gravitational attraction. If r is the separation between these two stars then their time period of rotation about their centre of mass is proportional is r^x and m^y, where x and y are constants. Determine the value of x and y.
   (a) $x = 3, y = -1$ (b) $x = \frac{3}{2}, y = -\frac{1}{2}$ (c) $x = 2, y = 2$ (d) $x = 1, y = 1$

4. A fish in an aquarium approaches the left wall at the rate of 3 m/s and observes a fly approaching directly to it at 8 m/s. The refractive index of water is 4/3. The actual velocity of the fly is
   (a) 3.75 m/s (b) 2.75 m/s (c) 0.75 m/s (d) 4.75 m/s

5. A light airplane is headed due south at a speed of 300 kmph relative to still air. After 1 hour the pilot notices that they have covered only 240 km but the direction shown on compass is SSE. Assume the wind velocity to be constant. The wind speed must be
   (a) 210 kmph (b) 121 kmph (c) 65 kmph (d) 41 kmph

6. A is 65 × 65 matrix with $A^t = -A$. det A is
   (a) -1 (b) 65 (c) 1 (d) 0

7. The equation $x^2 - \sqrt{x+1} = 0$ has a solution in
   (a) [1,2] (b) [0,1] (c) [0, 1/2] (d) {0,1}

8. Suppose six children are marching in a circle. In how many different ways can they form their circle?
   (a) 4 (b) 4! (c) 5! (d) 6!

9. How many positive integers not exceeding 1000 are divisible by 7 or 11?
   (a) 232 (b) 220 (c) 244 (d) none of these

10. A reflector telescope has a spherical mirror of focal length 750 mm. What should be the maximum focal length of an eyepiece so that a normal human eye can just resolve a binary with separation 3 arc second?
    (a) 9 mm (b) 25 mm (c) 32 mm (d) 40 mm

11. A pendulum clock loses 12 seconds per day at temperature 40° C and gains 4 seconds per day at temperature 20 °C. The temperature at which the clock will show correct time, and coefficient of linear expansion of the pendulum shaft are respectively
    (a) 25° C, $\alpha = 1.85 \times 10^{-5}/°C$ (b) 24° C, $\alpha = 1.85 \times 10^{-4}/°C$
    (c) 35° C, $\alpha = 1.85 \times 10^{-2}/°C$ (d) 27° C, $\alpha = 1.85 \times 10^{-3}/°C$

12. During an adiabatic process, $P^3 \, \alpha \, V^{-4}$. The adiabatic ratio must be
    (a) 9/7 (b) 7/5 (c) 5/3 (d) 4/3

13. A satellite is in a circular LEO (low earth orbit) at a distance of 1000 km from the surface of the earth with velocity v. Its rockets are now fired, and it is imparted an additional velocity v directed towards the earth in negligible time. What can be said about the new orbit of the satellite?
    (a) The satellite will continue to remain a circular orbit.
    (b) The satellite will follow a spiral path and fall back to earth.
    (c) The satellite will move along a parabolic path.
    (d) The satellite will orbit the earth in an elliptical path.

14. Voyager 1 is currently 166 AU away from Earth. A signal was received from Voyager 1 and it was replied instantaneously. After how many hours will the reply reach to Voyager 1 after the transmission by Voyager 1?
    (a) 11.5 hours
    (b) 23 hours
    (c) 46 hours
    (d) Never, as it has crossed the Heliopause boundary

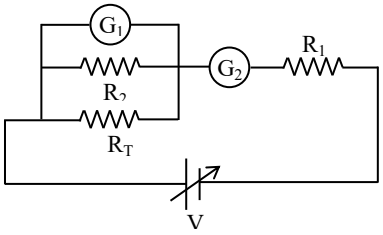
15. Statement I: A satellite having an orbital period of $24\,h$, appears stationary as seen from the Earth's surface.
    Statement II: Time period of a geostationary satellite is $24\,h$.
    (a) Statement I is true, statement II is true; statement II is a correct explanation for statement I.
    (b) Statement I is true, statement II is true; statement II is NOT a correct explanation for statement I.
    (c) Statement I is true; statement II is false.
    (d) Statement I is false; statement II is true.

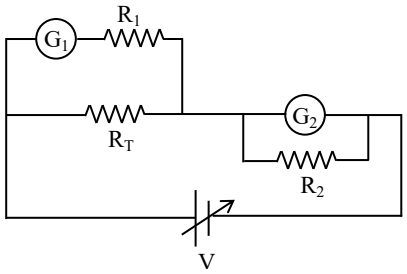
16. If there is a total solar eclipse on 21st June, what should be the approximate declination of Moon?
    (a) 0° (b) 5° (c) 23.5° (d) 28.5°

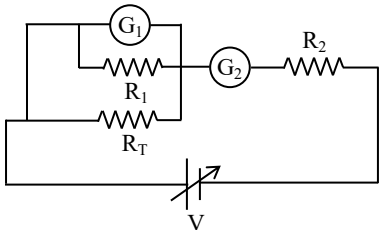
17. The absolute magnitude of the Sun and Sirius are $M_{\odot} = 4.8$ and $M_{Sir} = 1.4$, respectively. If the Sun were replaced by Sirius in the solar system, from which planet will it appear as bright as current appearance of the Sun from the Earth?
    (a) Jupiter (b) Saturn (c) Mars (d) Uranus

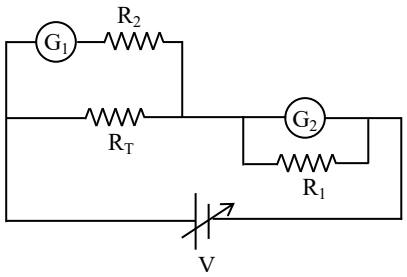
18. Messier catalogue contains which of the following celestial objects?
    (a) asteroids (b) comets (c) galaxies (d) pulsars

19. During the verification of Ohms law, a student is provided with a test resistor R_T, two resistors R_1 =10 kΩ & R_2 = 10 Ω, two identical galvanometers G_1 & G_2 and a variable voltage source V. The correct circuit to carry out the experiment is

(a) 

(b) 

(c) 

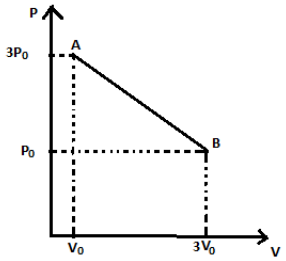
(d) 

20. A star's spectral line is observed to be shifted from $500\ nm$ to $505\ nm$. What is the star's radial velocity relative to the observer?

(a) $3 \times 10^3\ \mathrm{m \cdot s^{-1}}$ away from the observer. (b) $3 \times 10^3\ \mathrm{m \cdot s^{-1}}$ towards from the observer.

(c) $3 \times 10^6\ \mathrm{m \cdot s^{-1}}$ away from the observer. (d) $3 \times 10^6\ \mathrm{m \cdot s^{-1}}$ towards from the observer.

21. One mole of an ideal gas undergoes a process A → B as shown in the figure. Maximum temperature of the gas during the process is



(a) $\frac{4P_0V_0}{nR}$

(b) $\frac{3P_0V_0}{nR}$

(c) $\frac{P_0V_0}{nR}$

(d) $\frac{2P_0V_0}{nR}$

22. Two cities A and B are connected on the opposite ends of a long straight parallel track. These cities are connected by a train service as well as a bus service. The trains leave at constant speed v for either city at regular frequency of one train every x minute. The buses play on a parallel road at a constant speed of 30 km/hr. A bus passenger going from city A to city B observes a train going past him every 20 minutes while a train goes in the opposite direction in every 10 minutes. What are the values of x and v?

(a) 15 min, 90 km/h (b) 15 min, 75 km/h

(c) 13 min 20 s, 90 km/h (d) 13 min 20 s, 70 km/h

23. Value of the expression $\left(1+\frac{1}{1+\frac{1}{1+\frac{1}{1+\frac{1}{\ddots}}}}\right)$ is

(a) an integer (b) a rational number (c) an irrational number (d) infinity

24. If A is a 4 × 4 matrix with determinant 2, what is the determinant of 5A?

(a) 10 (b) 25 (c) 625 (d) 1250

25. For $x, y \in \mathbb{R}, xRy \Leftrightarrow$ there exists $c \neq 0, c \in \mathbb{R}$ such that $y = cx$ then

(a) R is reflexive (b) R is transitive (c) R is symmetric (d) All of these

26. $x^3 - 15x + 1 = 0$ has ……solutions in the interval $[-4, 4]$
    (a) 0 (b) 1 (c) 2 (d) 3

27. Which of the following is/are true for the function $f(x) = x\,|x|$ where $\mathbb{R}$ is the set of real numbers
    (a) f is twice differentiable at 0
    (b) f is once differentiable at $x = 0$ but not twice differentiable.
    (c) f is not differentiable at 0.
    (d) f is discontinuous at $x = 0$

28. Let a reflection about a line L passing through origin which makes an angle θ with the X-axis be denoted as Ref(θ) and A denote the matrix representation of Ref(θ) then A^{100} is
    (a) $\begin{bmatrix}1 & 0\\ 0 & 1\end{bmatrix}$ (b) $\begin{bmatrix}1 & 0\\ 0 & -1\end{bmatrix}$
    (c) $\begin{bmatrix}\cos 100\theta & \sin 100\theta\\ \sin 100\theta & -\cos 100\theta\end{bmatrix}$ (d) $\begin{bmatrix}\cos 200\theta & \sin 200\theta\\ \sin 200\theta & -\cos 200\theta\end{bmatrix}$

29. The number of real values of x that satisfy the equation $e^{4x} + e^{2x} - 2 = 0$ is
    (a) 0 (b) 1 (c) 2 (d) 3

30. In Young's double slit experiment, the slit separation is twice the wavelength. Maximum number of possible interference maxima is
    (a) 2 (b) 3 (c) 5 (d) 6

31. If the Sun sets 6 pm on a particular day, what approximate time should Venus set if it is at greatest western elongation?
    (a) 9 pm (b) 6 pm (c) 6 am (d) 3 pm

32. Statement I: Geminid meteor shower is caused on particular days of a year.
    Statement II: Every year on the same days, Gemini constellation rises at the same time.
    (a) Statement I is true, statement II is true; statement II is a correct explanation for statement I.
    (b) Statement I is true, statement II is true; statement II is NOT a correct explanation for statement I.
    (c) Statement I is true; statement II is false.
    (d) Statement I is false; statement II is true.

33. An electrical circuit consists of a constant voltage source, an ideal ammeter and a variable resistance *R* connected in series. A voltmeter V is also connected across *R*. Ammeter readings *I* for known values of *R* are as shown in the table given below.

Obs. No.	1	2	3
R in kΩ	10	20	40
I in μA	900	600	450

    Value of the voltmeter resistance is
    (a) 400 kΩ (b) 40 kΩ (c) 30 kΩ (d) 20 kΩ

34. *P*, *V* and *T* obey the relation $PV = (aT - bT^3)$ for a certain material. Work done by the material if its temperature is isobarically increased to $2T$ is
    (a) $2aT - 8bT^3$ (b) $aT - 15bT^3$ (c) $aT - 7bT^3$ (d) $2aT - 7bT^3$

35. Arrange the following types of stars in order of increasing surface temperature.
    (a) Yellow dwarf, Brown dwarf, Red giant, Blue giant
    (b) Brown dwarf, Yellow dwarf, Blue giant, Red giant
    (c) Red giant, Blue giant, Yellow dwarf, Brown dwarf
    (d) Brown dwarf, Red giant, Yellow dwarf, Blue giant

36. Astronaut visiting the Mars watches the sunset from its equator. Mars is at 1.52 AU distance from the Sun. Approximately for how much duration the sunset will last?
    (a) 60 s (b) 80 s (c) 120 s (d) 150 s

37. Which of the following star is a part of Summer Triangle?
    (a) Betelgeuse (b) Sirius (c) Fomalhaut (d) Deneb

38. Approximately how much later would the moon rise as compared to the previous moonrise, if it were half the present distance?
    (a) 165 min (b) 90 min (c) 35 min (d) 30 min

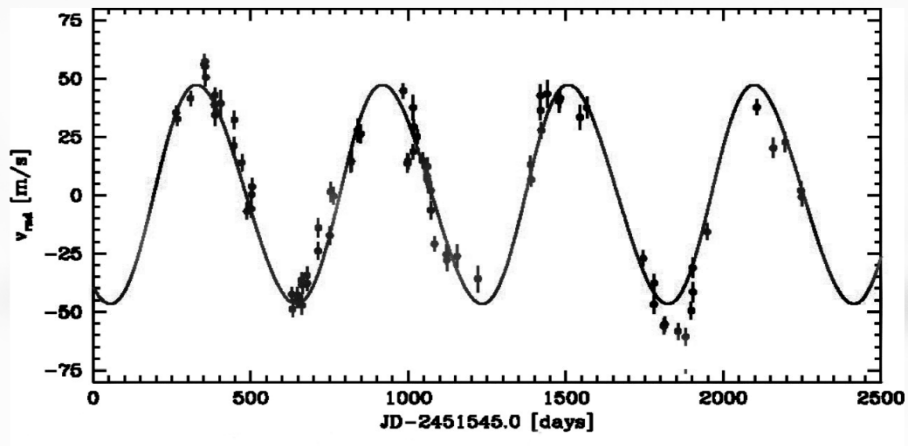
39. The solar constant is the amount of energy received per unit area from the sun at Earth and it is about 1400 $\mathrm{Wm^{-2}}$. A star has a luminosity of $1.6L_{\odot}$. This star is observed to have a flux of $24.92 \times 10^{-14}\,\mathrm{Wm^{-2}}$. The distance to this star from the earth is
    (a) 225 pc (b) 380 pc (c) 450 pc (d) 600 pc

40. The non-zero solution of the equation $\sin x = x \cos x$ is about 5%
    (a) smaller than $\pi/2$ (b) smaller than $3\pi/2$
    (c) larger than $3\pi/2$ (d) larger than $5\pi/2$

41. If $\begin{vmatrix} x & y & z \\ a & b & c \\ p & q & r \end{vmatrix} = 9$, then $\begin{vmatrix} x-2p & y-2q & z-2r \\ 2a & 2b & 2c \\ p & q & r \end{vmatrix}$ =?
    (a) 18 (b) 0 (c) -9 (d) -18

42. If A is a non-singular matrix of order $n \times n$, then the rank of A is
    (a) n (b) n – 1 (c) n + 1 (d) 0

43. When a planet orbits a star, the star appears to wobble as seen from the Earth. The wobble is measured in terms of Radial Velocity (RV). The RV plot below for the star Pollux in the constellation of Gemini, shows that there is at least one planet orbiting the star. If the mass of Pollux is $M_{pollux} = 1.86M_{\odot}$, what is the average distance of the planet from the star?



    (a) 0.75 AU (b) 1.2 AU (c) 1.5 AU (d) 1.7 AU

44. In a visual binary system, the difference in the apparent magnitudes of the two stars is 2, the hotter component being the brighter. If the surface temperatures of the two stars are 12000 K and 6000 K, calculate the ratio of the hotter star's radius to that of the cooler star.
    (a) 0.40 (b) 0.63 (c) 1.60 (d) 2.52

45. Which of the following statements about the Pole Star (Polaris) is correct?
    (a) it is the brightest star in the night sky
    (b) it is located exactly above the Earth's North pole
    (c) It is never visible from 20°S latitude
    (d) Polaris is the closest star to the Sun

46. Which digit appears in the unit's place of the number $(((7^7)^7)^{\cdots})^7$ (total fifty 7s)?
    (a) 9 (b) 7 (c) 3 (d) 1

47. From a particular location on the Earth it is observed that a star A rises a few minutes before star B. Which of the following statements is correct?
    (a) star A will rise the same duration before star B, as seen from the same location on any other day.
    (b) star A will set before star B, as seen from the same location
    (c) star A will rise before star B, as seen from any other location on the Earth.
    (d) star A will set the same duration after star B, as seen from the same location.

48. For which of the following functions, area between the curve and X axis in [0, 1] is NOT finite?
    (a) $\sin^{-1} x$ (b) $(x - 0.5)^2$ (c) $\cos^{-1} x$ (d) $\cot x$

A – 2

ANY NUMBER OF OPTIONS (4, 3, 2 or 1) MAY BE CORRECT

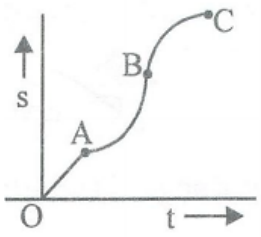
MARKS WILL BE AWARDED ONLY IF ALL THE CORRECT OPTIONS ARE BUBBLED AND NO INCORRECT.

49. Persons A and B are sitting at diametrically opposite points on a turntable rotating with constant angular velocity in anticlockwise direction as seen from top, while person C is outside the turntable standing steady on the ground. Neglecting rotation and revolution of the Earth, which of the following statement/s are correct as seen by A?
    (a) B is at rest and hence does not experience radially outward force.
    (b) C is moving in clockwise direction but does not experience any physically outward force.
    (c) B is at rest and experiences fictitious outward force which is only in imagination.
    (d) A is at rest and does not experience any physically outward force.

50. While observing a star, by measuring the energy of the light emitted, it is possible to directly estimate the
    (a) elements and molecules present in the core of the star.
    (b) elements and molecules present in the atmosphere of the star.
    (c) luminosity of the star.
    (d) flux of the star measured by the observer.

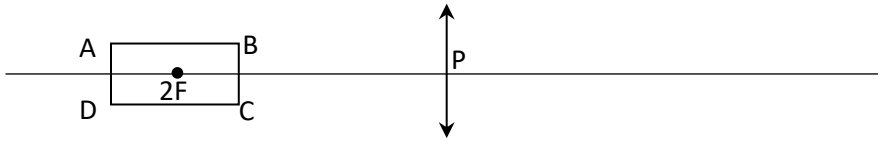
51. The sunlit side of the moon's surface can reach a temperature of 400 K and the side opposite to the sun facing surface can reach a temperature of 140 K, while the coldest spots near the lunar poles can be at a temperature of 20 K. The moon will appear bright in the wavelengths around
    (a) 19 – 21 μm when observed the dark side.
    (b) 500 – 550 nm anytime.
    (c) 700 – 750 nm when the sunlit side is observed.
    (d) 120 μm when the lunar poles are observed.

52. Displacement (s) against time (t) graph of a particle moving in a straight line is as shown in figure. Select correct alternative:
    (a) The acceleration of the particle in region OA is in the direction of motion.
    (b) Work done by forces in region AB is positive.
    (c) Work done by forces in region OA is positive.
    (d) The acceleration of the particle in region BC is opposite to the direction of motion.



53. For the equation $2x + y - 6 = 0$ which of the following equation has geometric representation such that the pair so formed is parallel lines
    (a) $4x + 2y = -2$ (b) $5x + 3y = 6$ (c) $6x + 3y + 6 = 0$ (d) $x + 2y + 3 = 0$

54. Figure below shows rectangular plane lamina ABCD, kept symmetrical to the principal axis of a convex lens of focal length 30 cm. Centre of the lamina is at the distance 2f from the pole P of the lens. $l(AB) = 30$ cm and $l(AD) = 12$ cm. Select option/s about the image formed.



    (a) Images of the edges AD and BC are not straight lines
    (b) Area of the image of lamina is 400 cm^2
    (c) Shape of the image is trapezoidal
    (d) Area of the image of lamina is between 320 cm^2 and 400 cm^2

55. Which of the following parameters does the period of the Moon around the Earth depend upon? Both the Earth and the Moon are assumed to be spherical in shape.
    (a) mass of the Moon
    (b) mass of the Earth
    (c) radius of the Moon's orbit
    (d) inclination of the orbit to the equatorial plane

56. A lunar eclipse is observed on 15th March in a particular year. On which of the following days the solar eclipse is possible?
    (a) 30th March (b) 28th April (c) 25th August (d) 9th September

57. The Schwarzschild radius of a black hole is:
    (a) The distance from its center at which gravitational force becomes infinite.
    (b) The radius of the event horizon.
    (c) The radius at which the escape velocity from the black hole equals the speed of light.
    (d) The distance at which time stops relative to a distant observer.

58. 8 unbiased coins are tossed.
    (a) there is less than 20% chance that less than 3 coins will land heads.
    (b) there is more than 2/3rd chance that 4 or more coins may land heads.
    (c) there is less than 1/3rd chance that exact 4 coins will land heads.
    (d) there is more chance that total of 1 or 2 coins will land heads than exact 4 coins will land heads.

59. Consider a square of unit side.
    (a) area of circumcircle is 2 times area of incircle for the given square
    (b) area of a square for which incircle of the unit square is circumcircle is half square units
    (c) area of the circumcircle of the unit square is equal to $\pi/2$ square units
    (d) area of incircle of the unit square is $\pi/2$ times area of a square inscribed inside the incircle

60. Consider function $f(x) = |\sin x| + |\cos x|$ in the range $(-\pi, \pi)$.
    (a) there are 5 points where $f(x)$ is discontinuous
    (b) there are 3 points where $f(x)$ is not differentiable
    (c) there are 4 points where $f'(x) = 0$
    (d) there are 3 points where $f'(x)$ is discontinuous

Rough Work